Barriers, drivers and enablers for transitioning towards innovation in the Australian water sector

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Abstract
The Australian water sector needs to adapt to effectively deal with the impacts of climate change on its systems. Challenges as a result of climate change include increasingly extreme occurrences of weather events including flooding and droughts (Pittock, 2011). In response to such challenges, the National Water Commission in Australia has identified the need for the water sector to transition towards being readily adaptable and able to respond to complex needs for a variety of supply and demand scenarios (National Water Commission, 2013). To successfully make this transition, the sector will need to move away from business as usual, and proactively pursue and adopt innovative approaches and technologies as a means to successfully address the impacts of climate change on the Australian water sector.

In order to effectively respond to specific innovation challenges related to the sector, including climate change, it is first necessary to possess a foundational understanding about the key elements related to innovation in the sector. This paper presents this base level understanding, identifying the key barriers, drivers and enablers, and elements for innovative practise in the water sector. After initially inspecting the literature around the challenges stemming from climate change faced by the sector, the paper then examines the findings from the initial two rounds of a modified Delphi study, conducted with experts from the Australian water sector, including participants from research, government and industry backgrounds. The key barriers, drivers and enablers for innovation in the sector identified during the initial phase of the study formed the basis for the remainder of the investigation. Key elements investigated were: barriers – scepticism, regulation systems, inconsistent policy; drivers – influence of policy, resource scarcity, thought leadership; enablers – framing the problem, effective regulations, community acceptance.

There is a convincing argument for the water sector transitioning to a more flexible, adaptive and responsive system in the face of challenges resulting from climate change. However, without first understanding the challenges and opportunities around making this transition, the likelihood of success is limited. For that reason, this paper takes the first step in understanding the elements surrounding innovation in the Australian water sector.

Keywords
Australia, Delphi, innovation, sustainability, water.

1. Introduction
The water sector is the foundation for one of the most precious commodities on earth. It provides us with the ability to source, supply, treat and distribute water to communities. Sustaining these abilities is critical, and to do that the sector must continue to adapt and evolve, which requires continuous innovation. That is why this research argues that understanding the key elements for improved innovation in the Australian water sector will form a basis to contributing more sustainable outcomes for the sector.

Much of the water infrastructure that exists today is primarily shaped by the legacy of traditional systems (Department of Infrastructure and Transport, 2012), which may no longer be the most efficient, sustainable or resilient options to provide for 21st Century society. Globally, the water sector faces a number of serious threats. The Australian water sector in particular, has always been exposed

to variability that the landscape and climate bring. However, with the projections of future challenges in the sector, continued and increased responsiveness and adaptability will be essential to ensure a sustained level of service now and into the future. Key challenges faced by the water sector include:

- climate change;
- increasing population; and
- resource scarcity.

2. Challenges and contemporary needs

2.1 Climate change

There is clear scientific consensus that anthropogenic climate change is occurring, however, the exact scale and timing of the effects are still uncertain (Elements Strategic and Risk Management, 2012). Despite this uncertainty around the specifics, climate change predictions for Australia suggest: (National Water Commission, 2012, Elements Strategic and Risk Management, 2012)

- increased variability of temperature and rainfall;
- increased occurrence of extreme weather events such as fires and floods;
- sea level rises.

The natural water cycle is highly sensitive to climactic changes, which means that the water sector in Australia is facing an unprecedented challenge in responding to these changes. This is likely to impact all facets of the water sector, including (National Water Commission, 2012, Elements Strategic and Risk Management, 2012):

- water supply (reduced availability and reliability);
- demand for water (generally increased, but decreased in some localised areas);
- increased costs of service;
- increased risks to community and the environment;
- failure or life reduction of infrastructure and other assets;
- sewerage transfer and treatment; and
- drainage and flood management.

The National Water Commission (2012) contends that climate change and water management are two of the most important issues facing Australia. Aside from the impacts from climate change, the water sector faces other challenges such as an intensive dependence on resources, exacerbated by their increasing scarcity.

2.2 Resource scarcity

Australia has always been prone to fluctuations in the availability of water resources, and continued investment is required by organisations to maintain a sufficient supply of high quality water. Since the nationwide 'Millennium Drought' during the late 1990's and 2000's, organisations have begun developing greater interconnectivity to improve the resilience of supply security. However, the usual supply fluctuations are predicted to be exacerbated by the impacts of climate change (Australian Greenhouse Office, 2003) and population increases, meaning that current measures will not be sufficient to maintain water security into the future. In addition to water scarcity, the sector also needs to consider other key resources involved in the supply and distribution of water, such as energy and land. Using current practices, wastewater treatment plants require large amounts of space to process water. While the land availability in Australia is expansive, the increasing urbanisation of the population means that the locations with the greatest demand have the smallest land availability. Additionally, the cost of energy in Australia has been rising rapidly over the past decade (ESAA, 2012). The high energy intensity of many traditional and contemporary processes within the water sector, such as desalination, means that energy will become an increasingly key concern for water organisations to be able to deliver efficient, cost-effective solutions for consumers (US Department of Energy, 2006).

2.3 Increasing population

Like much of the world, Australia is already highly urbanised with 90% of the population residing in cities. Projections by the Australian Bureau of Statistics indicate a national population increase from

just under 23 million people in 2013, to up to 42.5 million by 2056 (Australian Bureau of Statistics, 2008), and it is forecasted that the majority of those people will be living in cities, which presents a major challenge for the 21st century (CSIRO Water for a Healthy Country Flagship, 2014). The key impacts of this population expansion include an increased demand for water, energy, land and materials; as well as increased generation of waste streams, stormwater runoff, nutrient flow and chemical contamination (CSIRO Water for a Healthy Country Flagship, 2014).

2.4 Contemporary needs

Each of these factors presents a significant challenge for the sustainability of the Australian water sector, and addressing them will require a departure from business as usual. Solutions will require flexibility and innovation, whilst still maintaining reliable and quality service for users. In order to effectively address specific issues such as those mentioned previously, including climate change, it is first necessary to establish a clear understanding of the underpinning elements that are conducive and inhibitive to innovation within the water sector. That's why this research is focused on presenting a foundational understanding of the key elements that will allow for innovative practices within the sector to allow for sustainable outcomes now and into the future.

The Organisation for Economic Co-operation and Development (OECD) identifies the following traits as being necessary for the future of infrastructure to cater for the progressive needs of society, including a need for:

- *reliable* and *resilient* infrastructure;
- meeting future *environmental* and *security* challenges;
- infrastructure development to effectively meet *social*, *environmental* and *economic* objectives;
- better *life-cycle management*; and
- better *efficiencies* through demand management (Organisation for Economic Co-operation and Development, 2007, p17).

The United Nations Environment Programme (2012) further notes that the infrastructure decisions made today will affect the future sustainability of cities for the medium to long-term. The transition towards more sustainable outcomes in the water sector will require changes to all aspects of the sector from the scientific and technical, to governance frameworks, to leadership and management practices. With respect to the challenges and requirements for the water sector previously mentioned, it is necessary to understand how we can enhance sustainability through improved innovation practices in the Australian water sector. This paper commences this investigation by:

- exploring the key barriers, drivers and enablers for achieving innovative results in the Australian water sector, through a rating-scale questionnaire; and
- identifying a range of strategies, tools or methods that may be useful in overcoming the barriers, drivers and enablers for innovation in the Australian water sector through an open-ended questionnaire.

These questionnaires were conducted as the pre-Delphi round and Delphi round 1 of a larger study around innovation in the Australian water sector.

3. Delphi method and application

The Delphi technique is essentially a group process used to collect the opinions and reach consensus of experts on a particular subject, usually through a series of questionnaires (Yousuf, 2007). The capability to discern in-depth information when limited historical data is available (Gupta and Clarke, 1996) makes this technique useful for foundational research of this nature. The Delphi technique is also a useful tool for gaining insight into complex problems in areas that are subjective (Okoli and Pawlowski, 2004, Skulmoski et al., 2007, Yousuf, 2007), such as determining the priority areas and best methods to address innovation in the water sector. Recognised limitations of the technique include the understanding that due to the niche sample of respondents, findings only offer a snapshot opinion rather than resolute verdict. The other key limitation that has arisen through literature is the necessity to ensure methodological rigour, and failure to do so is the most widely recognised concern. Based on the strengths, limitations and areas of concern discussed, the Delphi process was deemed

to be an acceptable and appropriate method for this research, assuming concerns about rigour of application are suitably addressed. The key matters that were considered when designing the Delphi study were:

- expert panel selection;
- sample size; and
- study design (i.e. number of rounds, questionnaire structure)

3.1 Expert panel selection

Selection of an appropriate panel of experts is one of the most important factors in the design of a Delphi study (Skulmoski et al., 2007). It is important to note that unlike traditional questionnaire methods, the Delphi approach does not require a statistically significant sample of a population, but rather relies on the opinion of a select group of high-level experts in the area of interest. Therefore, rigour around selecting experts is critical (Baker et al., 2006). In this case the experts are required to have a strong background in the Australian water sector, and both a breadth and depth of understanding about factors that may influence innovation within the sector. Further to these criteria, it is important to note that this research also required representation from three areas within the water sector, being: research, government, industry.

3.2 Sample size

There is an absence of consensus among the literature about the optimal number of participants in Delphi studies. Ludwig (1997) indicates that the majority of Delphi studies he has analysed have used between 15 and 20 participants. In a review of graduate studies using the Delphi method, Skulmoski (2007) noted that in general, the larger the sample size, the more accurate the result; but smaller sample sizes are adequate where verification of results is conducted with follow-up research like an interview. The final expert makeup is presented in Figures 1 – 4 and comprised CEO's, Directors, Group Managers and Research Leaders. The range of sectors represented (research, industry and government) as well as the variety and level of experiences provided a collective wisdom from the experts that laid a solid foundation for the validity and reliability of the Delphi study.

Of the 16 experts who agreed to participate, 13 completed the pre-Delphi questionnaire, with a response rate of 81%. Only the experts who completed a round were invited to take part in the subsequent rounds, so round 1 commenced with 13 experts.

3.3 Study design

This Delphi study was conducted across four rounds: one pre-Delphi round, plus three Delphi rounds. This paper presents and discusses the results from the pre-Delphi round and Delphi round 1.

The pre-Delphi questionnaire was developed based on the responses to interviews, which were conducted prior to the commencement of the Delphi study. This pre-Delphi round comprised a rating-scale questionnaire that was designed to determine which three barriers, drivers and enablers for innovation in the Australian water sector had the greatest potential to impact the state of innovation through further investigation. Experts were asked to rate each key statement on a sliding scale from 0 to 100 (0=lowest, 100=highest) against the following criteria:

- **Impact** of barrier, driver or enabler statement
- **Priority to address** barrier, driver or enabler statement

Delphi round 1 was designed as an open ended questionnaire, again comprising three categories: barriers, drivers and enablers for innovation in the Australian water sector. This round was designed to elicit thoughtful, in-depth responses from the experts to generate a comprehensive list of strategies, tools and methods to enhance innovation in the Australian water sector.

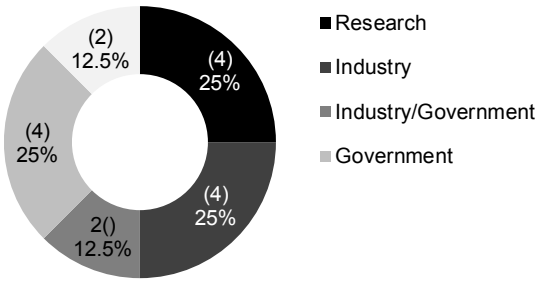

Figure 1: Type of organisation expert panel members are employed by

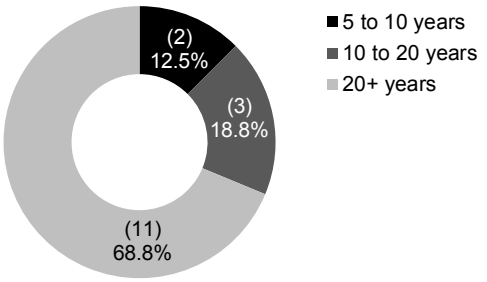

Figure 2: Number of years' experience in sector for expert panel members

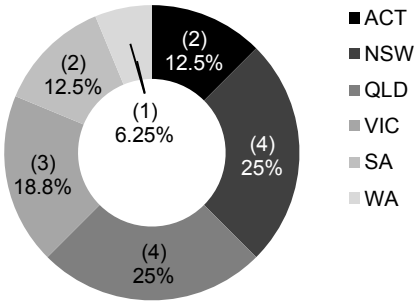

Figure 3: Geographic region expert panel members work in

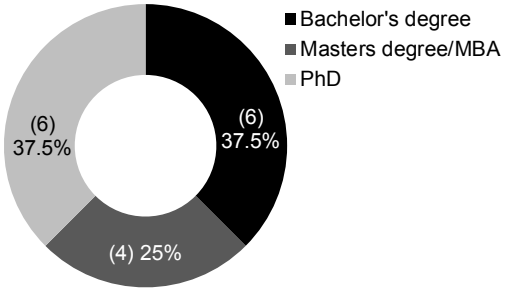

Figure 4: Highest level of academic qualification for expert panel members

4. Findings from experts based on pre-Delphi and Delphi round 1

4.1 Pre-Delphi round

The intention of the pre-Delphi questionnaire was to provide guidance around the key issues that would provide the most value for further investigation in the Delphi study. Each statement in the categories: barriers, drivers and enablers for innovation in the Australian water sector; was rated by the expert participants. These ratings, alongside findings from literature formed the selection process for identifying elements for further investigation.

4.1.1 Barriers

The three barriers identified by the experts for further investigation were:

- Inconsistent policy across political cycles;
- Scepticism or a need for proven results; and
- Regulation systems impede progress.

4.1.2 Drivers

The three drivers identified by the experts for further investigation were:

- Thought leadership and reaching for stretch targets;
- Influence of policy; and
- Increasing demand for/ scarcity of resources.

4.1.3 Enablers

The three enablers identified by the experts for further investigation, and displayed in Figure 5 are:

- Suitably framing the problem;
- Effective regulations; and
- Community acceptance.

The three barriers, drivers and enablers for innovation in the Australian water sector identified for further investigation then formed the basis for the development of the Delphi round 1 questionnaire.

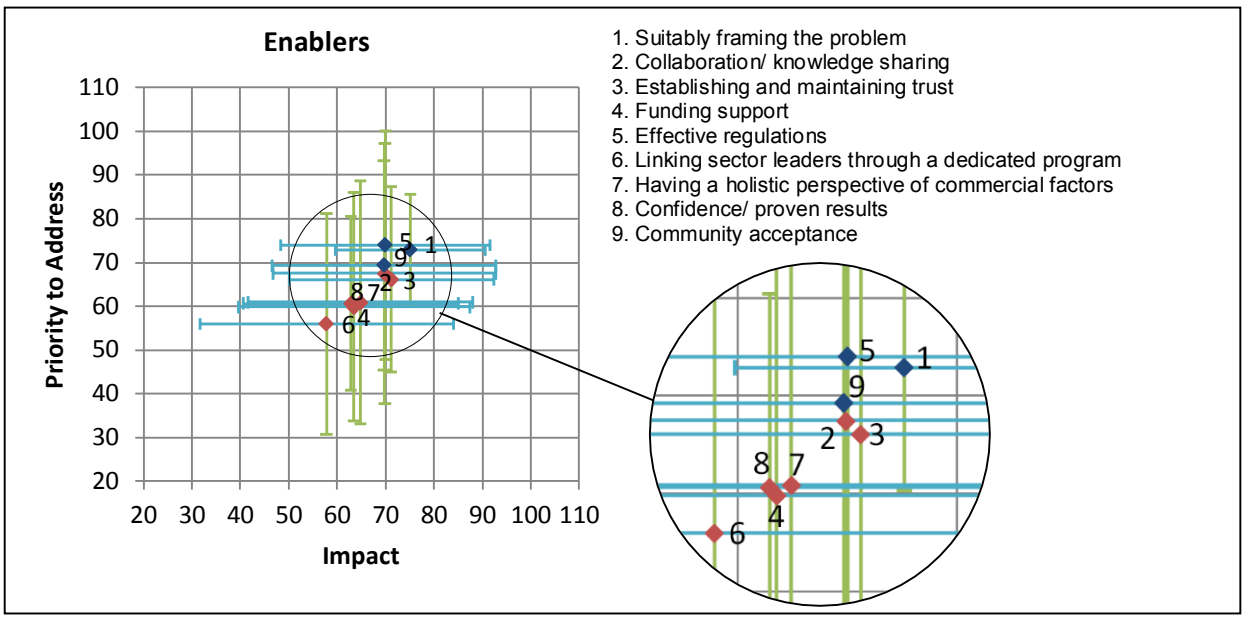

Figure 5: Sample result showing factors for innovation in the Australian water sector as rated in pre-Delphi questionnaire

4.2 Delphi round 1

Delphi round 1 was designed to elicit open-ended, qualitative responses from the expert participants. These responses were analysed using a content analysis approach to identify the major themes, with NVivo software. This analysis indicated a total of 43 tools, strategies or methods, which were split into nine key themes that could impact the state of innovation in the Australian water sector. Details of each theme are presented in Sections 4.2.1 through 4.2.9 and Appendix A lists all 43 elements discovered.

4.2.1 Diversity

The suggestions around diversity encompassed a range of subjects including the importance of actively engaging diverse people and opinions, such as the disciplines or perspectives involved in the conversation about priorities or solutions. This theme also tapped into another line of thinking, hitting on the benefits that may arise as a result of diversity in asset portfolio's e.g. by maintaining robustness and resilience of a system.

4.2.2 Collaboration

Collaboration for innovation may be facilitated between research and industry constituents, between various utilities, or within organisations. Suggestions for collaborative activities to enhance innovation include sharing data or exchanging lessons learned between different parts of the water sector; encouraging utilities collaboratively embracing the adoption of new ideas to share responsibility and spread risk; and involving stakeholders in policy development to ensure relevance to all parties in the sector.

4.2.3 Increasing the public profile of the water sector

The need to increase the public profile of the water sector as a means to enhancing innovation was a key suggestion put forward by the panel of experts. However, this appears to be a sector specific phenomenon specific to the water sector, and is not a theme that appears elsewhere in innovation literature. Strategies proposed for increasing the profile of the sector include the use of spokespersons and media engagement to increase awareness of water issues; public debate on key issues, facilitated by peak bodies; promoting successful initiatives; showcasing leadership; and the overarching element of developing a coherent voice for the sector.

4.2.4 Leadership

Leadership for innovation in the water sector includes the requirement for organisational leaders in the sector to trial and adopt new innovations, as well as engaging champions or advocates to support innovations. This is reminiscent of Walker's (1969) findings about diffusion of innovation among American states, where he noted that it was usual for intra-regional leaders to emerge, and common

for the surrounding states to follow their lead and adopt a new innovation only once the intra-regional leader had done so.

4.2.5 Culture

A variety of topics emerged within the culture theme, including discussion about the impact of organisational culture, and the cultural attitude towards water conservation held by the Australian public due to awareness campaigns implemented across the nation during the Millennium Drought in the 2000's. The topic of organisational culture is of particular interest, as the water sector is described as being particularly risk averse and conservative (Farrelly and Brown, 2011). Transforming this sector-wide cultural norm has the potential to have a significant impact on the sector. Additionally, the category included discussions about the place of competition to drive the adoption of innovation, which mimics the findings presented by Cave (2009) in his inquiry into competition and water markets in the UK.

4.2.6 Education

Educating the public about water issues and providing independent research to develop public understanding and acceptance was identified as an access to successfully introducing innovative concepts. The discussion within this category could easily be linked to the community engagement category as there is overlap with public education being an outcome of community engagement.

4.2.7 Regulation

Within the pre-Delphi interviews, discussion around regulation as an inhibiting or contributing element for innovation was discursive, with some experts believing there was need for regulatory reform to allow more freedom, and others believing the role that current regulations play have either negligent or positive impact on the ability to innovate within the water sector. Suggestions put forward within the regulation theme included: achieving a holistic understanding of the challenges resulting from current regulations and establishing a group of appropriately qualified people to suitably re-frame regulations; and the development of nationally consistent regulations. Another element that was proposed involved a strategy to ensure regulators are kept up-to-date with the latest best practise models globally.

4.2.8 Community engagement

Community engagement was the largest theme to emerge, with a variety of discussion around the importance of consistent, regular and transparent engagement with communities. This includes early engagement with community leaders, understanding the priorities and demands of the community, and allowing community input into decision making processes. As demonstrated by failed initiatives, such as the Toowoomba recycled potable water scheme, and the fluoridated water implementation project in the United States, communities can be a powerful influence on the success of an innovation or technology and effective engagement is crucial.

4.2.9 Other

There were a number of suggestions from the experts that contributed to the knowledge, but did not fit into a specific theme. These involved such elements as developing a strong business case for innovations, which is a continuously pertinent topic in many conversations, particularly in the sustainability sphere. Other elements included in this theme include the requirement to communicate ideas appropriate for the given audience, pricing and tariff reforms and encouraging and maintaining a long-term strategy for water organisations.

5. Concluding remarks

Each of the elements discussed has been proposed as being favourable to innovation in the Australian water sector in general. While many of these findings may seem promptly apparent to professionals currently working within the sector, this foundation-level information collation and ranking exercise is an important first step in building a knowledge base around the components for change and innovation within the sector. This knowledge base forms the underpinning for more specific lines of enquiry, such as those to address pertinent challenges to the sector, such as climate change, population changes and resource scarcity.

Findings presented from the pre-Delphi round indicated three key barriers, drivers and enablers for innovation in the Australian water sector that were worthy of further investigation. These areas were identified according to industry, government and researchers in the water sector as being: barriers – scepticism, regulation systems, inconsistent policy; drivers – influence of policy, resource scarcity, thought leadership; enablers – framing the problem, effective regulations, community acceptance.

The Delphi round 1 questionnaire uncovered 43 tools, strategies and methods; split into nine overarching themes that have the potential to impact the state of innovation in the Australian water sector. These themes: diversity, collaboration, increasing the public profile of the water sector, leadership, culture, education, regulation, community engagement, and other, will be further explored in the additional Delphi rounds 2 and 3 of the larger study. This further investigation will provide researchers, industry and government professionals in the Australian water sector an access to understanding the key elements that are conducive to innovation, and a guideline to effectively enhance innovation within their own organisations.

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Appendix A

Theme 1 – Diversity
Engaging multi-disciplinary leaders to develop a consensus about priority areas for the sector
Enlisting diverse perspectives to identify and frame the right problems and develop solutions
Diversifying portfolio's to ensure robust and resilient water supply
Theme 2 – Collaboration
Encouraging collaboration between utilities to share responsibility and spread risk for new ideas
Organisations working collaboratively to embrace adoption of new ideas
Sharing data or information to advance learning and exchange lessons learned
Involving stakeholders in policy development to ensure suitability to sector
Encouraging collaboration between researchers and industry
Realigning research KPI's to include transfer of technology to industry
Theme 3 – Increasing the public profile of the water sector
Increasing the profile of the water industry through spokespersons and media
Enhancing media engagement to increase interest and awareness of water issues and innovations
Peak bodies or associations providing public information or debate on key issues
Promoting and publicising results and successes of trials and initiatives
Showcasing achievements of organisations who are demonstrating leadership
Communicating with a coherent voice for the sector
Theme 4 – Leadership
Engaging champions or advocates to provide advice and support ideas
Leadership around trialing and adopting innovation from entities such as CSIRO or WSAA
Theme 5 – Culture
Developing a culture conducive to innovation within organisations
Maintaining the focus on cultural change that started with restrictions and became almost normal behaviour
Encouraging industry to embrace KPI's around innovation and support of new technology
Creating competition to drive adoption of innovation
Theme 6 – Education
Investing in public education about water issues
Independent science and research to support public understanding and acceptance
Theme 7 – Regulation
Understanding the challenges in current regulations from all perspectives
Ensuring regulators are kept abreast of latest developments and best practice models
Establishing a working group of sector leaders to partner with regulators to revisit and re-frame regulations
Nationally consistent regulations to foster streamlining and consistency whilst still maintaining appropriate standards
Public reporting to provide a holistic view of performance
Theme 8 – Community engagement
Ensuring transparent and open communication with communities
Engaging with community leaders to gain their support
Openly presenting benefits and risks of new and existing options to clearly show value of each option
Providing real choice for communities during engagement processes
Understanding community priorities and demands
Demonstrating clear feedback about where community contributions have been reflected in decision making
Ensuring community engagement is early and often
Theme 9 – Other
Communicating concepts appropriately for the given audience
Building a strong, evidence-based business case
Establishing benchmarks and link to awards for successful projects
Maintaining long term strategy to ensure organisational direction is on-track and prepared for opportunities
Opening the market to third party suppliers who may be in a better position to embrace new technology
Empowering customers to control their water use through smart monitoring
Pricing and or tariff reform to incentivise demand management
Using a risk based approach to decision making